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GEODESY.—*Some results of the Hayford method of gravity reduction.*[1] WILLIAM BOWIE, Coast and Geodetic Survey.

Geodesists have for years sought the cause or causes for the difference between the theoretical and observed intensity of gravity at any point of observation on the earth's surface. It was early found that gravity at any specified latitude varied with the elevation of the station above sea level. This change is given by the formula:

$$C_z = -0.0003086\,H$$

in which the correction is in centimeters or dynes and H, the elevation, is in meters, if we work in the Coast and Geodetic Survey system. A change in elevation of about 3 meters makes a difference of 0.001 dyne in gravity.

It was also realized that the topography, that portion of the earth which is above sea level, and the deficiency of mass in the oceans, must have an effect on the intensity of gravity. Several methods have been used in making the so-called reduction of gravity observations for the effect of topography.

The "free air" method ignores topography as if it had no effect whatever, or as if it were compensated for at zero depth.

The Bouguer method of reduction takes into consideration the topography near the station but ignores the distant topogra-

[1] Read before the Philosophical Society of Washington, October 26, 1912.

phy and the curvature of the earth in computing the effect on the intensity of gravity.

Mr. G. R. Putnam used what he termed the Faye reduction[2] which is a modification of the free air reduction in that a correction is applied for lack of compensation.

The new reduction, introduced by Hayford,[3] is based on the assumption that the earth's crust is in a state of approximate equilibrium called isostasy. Besides the correction for topography to the theoretical value of gravity, at any station, there is also applied a correction of opposite sign to account for the effect of the compensation. The effect of the topography and its compensation for the whole earth is considered at each station.

If the earth were composed of homogeneous material its figure of equilibrium, under the influence of gravitation and its own rotation, would be an ellipsoid of revolution. Owing to the fact that the materials are heterogeneous and that they have considerable viscosity, at least near the surface, there are departures from the ellipsoid of revolution in the sense that above each region of deficient density there is a bulge or hump on the ellipsoid and above each region of excessive density there is a hollow, relatively speaking. The bumps are the mountains, plateaus, and continents; the hollows the oceans. The land is floated because it is composed of relatively light material and the ocean floors are depressed because they are composed of unusually dense material. This condition of approximate equilibrium has been given the name of isostasy.

The deficiency of density or material in the earth's crust under the land and the excess in density under the oceans is called the isostatic compensation. This compensation occurs, or is supposed to occur, within the upper portions of the earth's crust and the depth to which it extends is called the depth of compensation. In the first investigation of isostasy by Hayford, entitled, "The figure of the earth and isostasy from measurements in the United States," the most probable value for this depth was

[2] See Appendix 1, Coast and Geodetic Survey Report for 1894.

[3] Fully described in Coast and Geodetic Survey Special Publication No. 10, 1912, The effect of topography and isostatic compensation on the intensity of gravity.

found to be 113.7 kilometers. This depth has been used in all the gravity reductions by the Hayford method.

For the purpose of making the computations, the earth's crust is assumed to be in a state of perfect isostasy, with each topographic feature compensated for by a deficiency or excess of mass directly under it, and it is assumed that this compensation is exactly equal in amount but of opposite sign and is uniformly distributed to the depth of compensation. The results of the investigations show that there are material divergencies from the assumed ideal conditions but it appears that these conditions are, on an average, near the truth.

The 124 gravity stations in the United States have been arranged in groups according to the character of the topography surrounding the stations. The groups are: Coast stations, stations in the interior not near mountainous regions, stations in mountainous regions below the general level, and stations in mountainous regions above the general level. The mean anomalies for each of these groups, with and without respect to sign, are practically the same as the mean anomalies for all of the stations in the United States. This indicates that there is no appreciable relation between the character of the topography and the gravity anomaly and it also indicates that the earth's crust, under each class of topography, is in a state of approximate equilibrium.

It was found that anomalies of the new method show some definite relations to certain geologic formations. In the Archeozoic and Proterozoic formations the anomalies, tho few in number, are all positive, and are larger than the average of all stations. This indicates that there is an excess of mass in the crust under these formations, or it may mean that the density of the surface material near the station is much greater than 2.67, the assumed average density, or the anomalies may be caused partly by a departure from a state of perfect isostasy and partly by a greater density near the surface. In the Cenozoic, Mezozoic, and Paleozoic formations the mean anomaly, with regard to sign, is nearly zero. There are only five stations in intrusive formations but their anomalies have a strong tendency to be negative.

Helmert's formula for theoretical gravity at sea level, in the Potsdam system:

$$\gamma_0 = 978.030\ (1 + 0.005302 \sin^2 \phi - 0.000007 \sin^2 2\phi)$$

was used in the Coast and Geodetic Survey investigations. The first term is the derived value for gravity at sea level at the equator. The constant 0.000007 was adopted by Helmert from the theoretical investigations of Weichert and Darwin, while the constant 0.005302 depends upon the flattening of the earth and the centrifugal forces due to its rotation, the first and second constants in the formula resulted from a discussion of about 400 selected gravity stations. Owing to the great range in latitude of the stations used by Helmert, his value for the second term of his formula has a high precision, but it seems probable that there were systematic errors in his reductions for topography at the several stations which introduced an appreciable error into his first term, the theoretical value of gravity at the equator.

The theoretical value of gravity at the stations in the United States were computed by Helmert's formula and then corrections for elevation of the stations, topography and compensation were applied. It was found that the mean difference between the observed gravity and the computed gravity was + 0.008 dyne and the probable error of this difference was ± 0.0014 dyne. As this difference is nearly six times its probable error it was believed that it represents a real error in Helmert's formula. It was assumed that this correction belonged to the first term. With this correction applied the formula for theoretical gravity at sea level is:

$$\gamma_0 = 978.038\ (1 + 0.005302 \sin^2 \phi - 0.000007 \sin^2 2\phi)$$

This assumption was proved correct for the first and second terms of the theoretical formula were computed by the method of least squares from the gravity stations in the United States, assuming that the mean anomalies for the several zones selected were due entirely to erroneous values of the coefficients in the Helmert formula. The resulting formula is

$$\gamma_0 = 978.038\ (1 + 0.005304 \sin^2 \phi - 0.000007 \sin^2 2\phi)$$

This formula differs from that one shown above only in the second term and then only by two in the last place. Owing to the much greater range of latitude in the gravity stations used

by Helmert the value of his second term appears to be the best one available.

It is believed that for the United States the formula which will give theoretical values for gravity which will be nearest to the observed values is:

$$\gamma_0 = 978.038\ (1 + 0.005302 \sin^2 \phi - 0.000007 \sin^2 2\ \phi)$$

Helmert's formula, mentioned above, and the Coast and Geodetic Survey formula are based on the Potsdam system and depend upon the observed value of the absolute gravity at that place. For any other system (the Vienna, for instance) the formula would differ only in the first term.

The change in the formula by the Coast and Geodetic Survey in no way affects the value of absolute gravity at Potsdam nor does it affect the observed relative gravity at any place. It does give us a different theoretical value of gravity from that obtained by the Helmert formula. It is possible that the new formula will give better values than the Helmert formula in countries outside of the United States, but this has not yet been tested.

If the theoretical value of gravity in the Potsdam system were desired for any place in the United States the gravity at sea level for the station in question should be computed by the new formula. From this value should be subtracted the corrections for elevation of the station above sea level, then should be applied a correction, which may be positive or negative, for the combined effect of the topography of the world and its compensation. This effect should be computed by the new method which is described in Coast and Geodetic Survey publication, entitled "The effect of topography and isostatic compensation upon the intensity of gravity" by Hayford and Bowie.

It has been shown that in the United States the probable error of a difference between the theoretical and actual value of gravity (or an anomaly) is ± 0.016 dyne. Therefore, the value computed as indicated above has an equal chance of differing more or less than 0.016 dyne from the value which would be obtained from relative pendulum observations at the point under consideration. The mean difference between the theoretical and actual values of gravity at 122 of the stations in the United States was 0.018 dyne.

It is possible that a still better theoretical value of gravity could be obtained by applying an additional correction estimated by means of the illustration in the second gravity paper[4] which shows by contours the gravity anomalies or differences between the theoretical and the actual values. This correction should be used with great caution, and especially when the new point is comparatively distant from an existing station. The map indicates that to a great extent the larger gravity anomalies are caused by local conditions. As an instance of this there is only a distance of forty miles between Washington and Baltimore while the gravity anomaly at the former place is +0.037 dyne and the anomaly at Baltimore is −0.011.

The severest test to which the Hayford method of gravity reductions can be subjected is a determination of the flattening of the earth from the stations in a limited area such as that of the United States. These stations are few in number and they have a very small range in latitude compared with the data used by Helmert in deriving his value of the flattening 1/298.3. The method employed by Helmert was used in deriving a flattening from the stations of the United States, which was found to be 1/298.4. A further test was made by deducing a flattening from the stations in the eastern portion of the United States and one from the stations in the western half. These two flattenings were found to be 1/297.8 and 1/299.6, respectively. Each of the three values of the flattening is evidently in close agreement with the Helmert flattening.

An attempt has been made to determine the depth of compensation from gravity reductions with little success. It seems to be certain that the depth of compensation can be determined with much greater precision from deflections of the vertical.

The Coast and Geodetic Survey is not making any gravity observations at present, but it is planned that additional stations will be established after a few years. It seems to be advisable to postpone further field work until more light has been thrown on the many problems connected with isostasy.

[4]The effect of topography and isostatic compensation upon the intensity of gravity; second paper, by Bowie.

PHYSICS.—*A new method and an instrument for determining the reflecting power of opaque bodies.* P. G. NUTTING, Bureau of Standards.

The reflecting powers of diffusely reflecting opaque bodies have heretofore been determined, so far as the writer is aware, only by indirect or laborious methods involving calculations or integrations and very considerable systematic errors. The method here described was proposed and used by the author in official tests early in 1911. Recently (May, 1912) several improvements were introduced, a specially designed precision instrument constructed and its sensibility and residual errors investigated.

The principle of the method is that of two parallel infinite planes, one of which is a diffuse illuminator and the other the surface whose reflecting power is to be determined. The relative brightness of the two planes is then the reflecting power of the non-luminous plane. The luminous plane may be a transmission screen provided it be non-selective as regards direction, wave-length and polarization of the transmitted light.

The practical application of this method requires the possibility of (1) using the planes of limited (rather small) area and (2) of determining the relative brightness of the two planes without sensibly disturbing the light distribution.

The planes were limited in the first design by a wooden frame lined with white paper about 20 cm. square, separating the two planes about 20 mm. This gave satisfactory readings but was later replaced, chiefly for mechanical reasons, by a brass ring heavily nickel plated and highly polished. Into this ring is inserted the modified Martens-König polarization photometer used to determine the relative brightness of the two planes at the center of the ring.

Figure 1 shows a plan and an optical diagram of the reflectometer. The ring is 150 mm. in diameter and 32 mm. wide with a side tube to admit the nose of the photometer. The photometer is one of the ordinary Martens-König photometers with specially cut (angle 21 deg,. index 1.52) glass wedges placed over the nose piece holes. These increase the angle of the centering beam to about 75 deg.; 90 deg. prisms do not allow suffi-

cient diffusion of light, while with no prisms at all the light is received at too nearly grazing incidence and the effect of surface impurities is too greatly enhanced.

The stand is simply a rack on which is placed first the card or other surface whose reflecting power is to be determined, then the ring, then the diffusing screen. This screen is a sheet of dense milk glass or porcelain rough ground on both sides. Even ordinary paper, if uncalendered and free from water marks

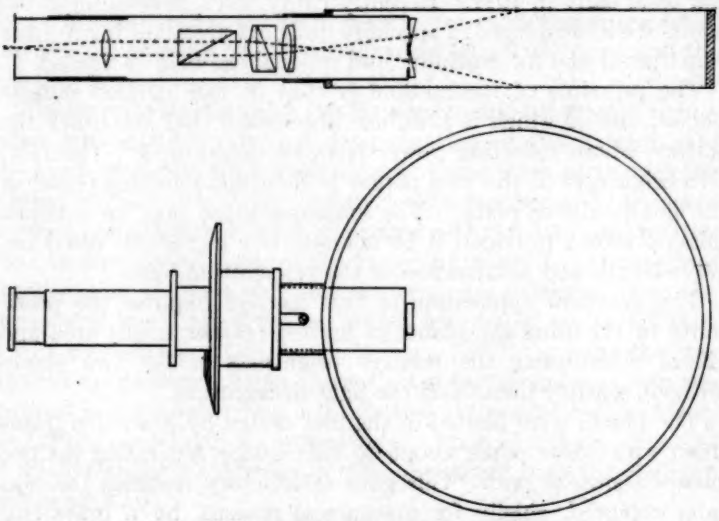

Fig. I. Plan of the reflectometer

will serve the purpose. Clear glass, even when ground on both sides, does not give correct results, on account of the increased percentage of normal transmission.

Readings are taken in four positions; in two quadrants with photometer direct, then in the same two quadrants with photometer reversed, thus eliminating the error of scale zero and determining the residual polarization. A screw head on the photometer engaging a slot on either side of the neck of the ring permits the ready reversal of the photometer.

The photometer circle is divided into single degrees. Successive settings agree usually to one or two-tenths of a division. The uncertainty in a set of five readings is not over half a tenth or 3 minutes of arc. The relative intensities of the entering beams are proportional to the square of the tangent of the angle indicated. The reflecting power is half the sum of those determined in the two principal azimuths.

Other forms of photometers might be used but a reversible polarization photometer is preferable. Polarization amounting to 5 to 10 per cent is the ordinary case in diffuse reflection and precision is to be attained by recognizing and determining the polarization.

The Martens-König design is admirably adapted for the purpose. The Wollaston prism gives a comparison between plane polarized light of one principal azimuth in one beam with that of the other principal azimuth in the other beam. Let S and X refer to light from the diffusing screen and unknown surface respectively. Then

$$\frac{S_\perp}{X_\parallel} = \frac{1}{R_1} \qquad \frac{S_\parallel}{X_\perp} = \frac{1}{R_2}$$

Now

$$\frac{S_\perp}{X_\perp} + \frac{S_\parallel}{X_\parallel} = \frac{S_\perp}{X_\parallel} + \frac{S_\parallel}{X_\perp} + e,$$

where e is a small quantity of lower order in all cases except when both $X_\perp$ and $X_\parallel$ are small and their ratio is large. This is the case of a surface of low reflecting power and high polarization, such as glossy black paper. Hence in all ordinary cases the reflecting power

$$R = \tfrac{1}{2} R_1 + \tfrac{1}{2} R_2$$

directly. In the special case mentioned it is best to compare the black surface directly with white paper or magnesia without using the ring.

The instrument was designed primarily for determining the absolute coefficients of reflection of reference standards, with which other surfaces may be readily compared, but it is convenient for many of the ordinary rough determinations as well.

For example by covering the diffusing screen by a color filter, the reflecting power may be found for any selected color. For wall coverings with their varied properties, this instrument probably gives a better mean value than any other except perhaps the integrating sphere and much more convenient. It is also serviceable for determining mean transmission coefficients in certain cases.

A sample set of readings is given below. The surface was that of a ground porcelain reference standard.

PHOTOMETER DIRECT		PHOTOMETER REVERSED	
Degrees	Degrees	Degrees	Degrees
47.8	132.1	41.1	139.0
8.0	2.2	1.2	8.8
7.8	2.1	1.1	9.0
7.7	2.4	1.1	8.9
7.9	2.2	1.1	8.8
Means. 47.84	132.20	41.12	138.90
	=47.80		=41.10

$\text{Cot}^2\ 47.82 = 0.8212 = R_1$
$\tan^2\ 41.11 = 0.7619 = R_2$

0.791 Reflecting power.

The correction to the zero is very small (mean 0°.03), the residual polarization about 3 per cent.

A few readings taken on various substances are given below as samples of the work done.

	R_1	R_2	R	PER CENT POLARIZATION
1. Boric acid powder, pressed mat	0.904	0.824	0.864	4
2. White bond paper	0.793	0.714	0.753	4
3. Ordinary white paper, single sheet over black	0.755	0.689	0.722	4
4. Same, several sheets thick.	0.766	0.699	0.733	5
5. Gray circular cover, with nap	0.418	0.417	0.417	
6. Same across nap	0.425	0.416	0.421	
7. Black card	0.060	0.105	0.082	27
8. Black velvet	0.012	0.023	0.018	30

The instrument may be used in the interior of a room or in full sunlight, direct or oblique, without variation in the reading. The chief sources of error to be guarded against are dirt on the diffusing screen and shadows falling upon it from nearby objects.

The writer is indebted to Mr. Lloyd Jones for able assistance in testing out the instrument.

This reflectometer or, properly, albedometer, promises to fill a want long felt by illuminating engineers. The design has been turned over to Schmidt and Haensch, makers of the Martens-König photometer.

ELECTROCHEMISTRY.—*The silver voltameter II.* E. B. ROSA, G. W. VINAL and A. S. MCDANIEL, Bureau of Standards. To appear in the Bulletin of the Bureau of Standards.

In the first paper of this series it was shown that the difference between the porous cup and the filter paper voltameter is due to the filter paper not being inactive. As the work progressed, it was found that the appearance of the deposit under the microscope was so reliable a criterion for the presence of such impurities as considerably affect the weight of deposit that the work has hastened by making many qualitative experiments in order to test a large number of substances which were added to pure silver nitrate in the hope of learning how the filter paper affects both the weight and appearance of the deposit.

Deposits made from pure $AgNO_3$ and water in a porous cup voltameter or one without septum are beautifully crystalline under the microscope. The crystals have sharp faces and angles, and between the crystals the platinum surface is clean and bright. From a slightly contaminated solution the deposit is often in long needle-shaped crystals or imperfectly crystalline and striated. As the impurity increases, the striations increase in prominence and the deposit looks more like slag with no easily detected crystalline structure. When the impurities are excessive, the deposits are grey and look more like lead than silver. In this qualitative work, the deposits were made in small voltameters and then photographed.

The action of filter paper on water was first investigated, and it was found that if the $AgNO_3$ solution was made from water that had been in contact with filter paper for even a short time the resultant deposit was strongly striated, and the electrolyte turned a reddish brown, suggestive of a colloidal solution. The same was true, no matter what quality of filter paper was used. Prolonged washing of the filter paper for twelve days even did not eliminate the effect. Writing paper, blotting paper, etc, all produced the same result, as did also papers made exclusively from wood, linen or cotton rag, and of the latter substances, wood fiber gave the most exaggerated effects.

The addition of acid to the pure electrolyte merely increased the number of crystals by decreasing their size, but did not affect the structure of the deposit. The effect of $CuSO_4$ and $Cu(NO_3)_2$ was similar. Silver acetate very greatly increased the number of crystals, making the deposit look like a field of snow. Gelatine, often used as an addition agent in electroplating, produced very exaggerated effects and a yellow solution apparently of colloidal silver.

By Bredig's method a considerable quantity of colloidal silver was prepared that was first of a neutral tint but after about a year turnd to an olive oil color. A sample of this was placed in a U tube between electrodes with 120 volts difference of potential. After twenty minutes it became certain that the colloid was traveling toward the cathode, and on reversing the current it moved in the opposite direction to the new cathode, finally hanging on it as a loose mass. A small quantity of this material added to $AgNO_3$ and electrolyzed modified the deposit in appearance. By using a porous cup as a filter, this colloid could be removed from solution and this suggested filtering a strongly contaminated $AgNO_3$ solution, which was done. The resulting deposit was crystalline and entirely free from striations. Because of the importance of this fact, further tests were made with similar results.

A systematic study of the chemistry of the voltameter eliminated the possibility of the observed effects being due to impurities in the filter paper or to the formation of silver hyponitrite,

as suggested by Smith, and led to a question of the behavior of cellulose and silver nitrate solutions.

The present authors observed in their qualitative experiments that the striations could be produced only by adding strong reducing agents to the electrolyte. Such weak reducing agents as starch and cane sugar were without effect. This fact, together with the possibility of preparing red colloidal solutions by the action of filter paper alone on silver nitrate solution showed that cellulose must act as a strong reducing agent. The identity of the colloid was fully established. Experiments showed that the extract of filter paper was 1000 times as active in reducing $AgNO_3$ as cane sugar, and emphasized the seriousness of filter paper as an impurity. The result of a long series of experiments led to the conclusion that the reducing action on $AgNO_3$ solutions takes place through the formation of oxycelluloses, probably decomposing into furfuraldehyde or some of its homologues. Since pure cotton cellulose is a hexopolyose, and not generally considered as yielding furfuraldehyde, careful tests by Forster's method were made which showed it to be present. A pure electrolyte containing 0.001 per cent of polymerized furfural when electrolyzed gave a strongly striated deposit similar to that of the filter paper voltameter. It is the authors' belief that oxycelluloses constitute the soluble furfural-yielding substances, and that after being extracted they are again formed by oxidation in the air, and hence the filter paper does not lose its power to produce striated deposits. The oxycellulose solution is colloidal in character, and very permanent. When it is added to silver nitrate solution, a red colloidal solution is obtained which is not readily coagulated owing to the protective action of the organic colloid. Some of the hydrogel obtained from these red colloidal solutions was found by analysis to be 97 per cent silver, the remaining 3 per cent being organic material. Further confirmatory evidence is obtained from carefully following the acidity changes of solutions of $AgNO_3$ treated with the extract from filter paper.

With such good evidence of the presence of silver colloids in contaminated solutions supported by actual observations on the

colloids by the ultra microscope, it seemed probable that the excess weight and the changes in structure of the deposit were due to this colloid.

The authors have formulated a theory to account for the change from the crystalline deposits of pure solutions to the noncrystalline and striated deposits of the impure solutions. In 1876, Kirmis, working under Helmholtz, made a study of the various forms of silver deposit but failed to offer any explanation of the cause of striations. Nearly twenty years later, Behn, working under Kundt, published an elaborate study of striated deposits. He carried out many ingenious experiments, and proved conclusively that the direction of the striae is the direction of the convection currents, as we have also done, but his explanation of filaments in the liquid as the cause of striations is not satisfactory, as he himself acknowledges. The explanation offered by Smith, Mather and Lowry is somewhat similar to Behn's. The strongest argument against their theories is that the striations disappear completely when the electrolyte is pure, all other conditions remaining the same.

Since the reducing impurities mentioned, which produce striations also produce colloidal silver when added to the electrolyte, it appears that the first essential condition for striations is the presence of a colloid that will be deposited on the cathode. The second essential condition is a motion of the liquid over the cathode surface. On the under side of a horizontal cathode, where convection currents along the surface are eliminated, the deposit is characteristic of an impure solution (if that is used) except that there are no striations. This and numerous other experiments establish the second condition. It is, of course, well known that the deposit from a cyanide solution of silver and potassium appears continuous under a very high power microscope, while a discontinuous deposit is obtained from a nitrate salt. As Ohm's law holds in the electrolyte, it is evident that there is at the surface of the platinum a potential difference opposing the current which brings the electrolyte in contact with the platinum to a higher potential than that of the electrolyte in contact with the silver, and so the currents diverted from the

platinum surface find numerous outlets to the platinum thru the silver crystals. The surface potential difference taken in connection with the specific resistance of the electrolyte and the current density determines the distance apart of the crystals, and, as will be shown, the striations also.

Based on these experiments, the following explanation of striations is given by the authors. The regular crystalline growth of the silver is according to the cubic system. Each ion, deposited as an atom, is constrained to occupy such a place that the crystal grows into a definite shape. But the growth may be broken up by the relatively large colloidal particles which are deposited, if present, and these form new nuclei for crystalline growth. The more colloid there is present, the more the regular crystalline structure will be interfered with. When the current starts, the deposit begins at many isolated points without definite arrangement, and these will grow into regu ar crystals if allowed to take their own course, but if the colloid destroys the crystalline structure, these masses of silver will grow in the direction of the convection currents of liquid, and eventually one crystal will grow into the one above it (if the currents are vertical as in the ordinary voltameter) and that in turn into the one above it, until the deposit is in the form of the familiar striae. In the case of pure electrolyte the "crystallizing force" overcomes this upward tendency of the convection currents, but it is possible to force striations in a pure electrolyte by making the velocity of the liquid over the surface great enough to overcome the crystallizing force. This has been accomplished by rapidly rotating a piece of platinum in a horizontal plane in pure electrolyte, and so obtaining spiral striae. This explanation is believed to be adequate and in accord with all the known facts.

The third paper of this series will give in detail the process for obtaining silver nitrate of sufficient purity for use in the silver voltameter and report the second series of quantitative measurements. The methods previously used for purifying the salt have proved to be unsatisfactory for work of the highest precision with the voltameter.

GEOCHEMISTRY.—*Electrical potentials between conducting minerals and solutions.* ROGER C. WELLS, Geological Survey. Communicated by George F. Becker.

In a recent paper V. H. Gottschalk and H. A. Buehler[1] pointed out the fact that differences of potential may exist between conducting minerals and solutions. Their measurements were made with water as electrolyte and a piece of copper as reference electrode. I have recently carried out a large number of measurements with various minerals and solutions using the normal calomel electrode as a reference electrode. It seems appropriate to state a few of the more important conclusions at this time.

I find in general that the potential shown by a conducting mineral depends chiefly upon the solution in contact with it and to a less extent upon the mineral. In its electromotive behavior pyrite is so slightly attacked that it functions practically like a piece of smooth platinum. To such an electrode acid and oxidizing solutions give a positive charge which may amount to a volt or more in air, whereas alkaline or reducing solutions yield lower values. The electrode may even assume a negative value of one or two tenths of a volt in the most alkaline reducing solutions. I conclude, therefore, that such potentials simply measure in an electrical way the oxidizing power of the solutions, the mineral playing a very insignificant part. Very careful experiments were made to see if the presence of air could affect the values. It was found that the values obtained with every precaution to exclude air were practically the same as those shown in the presence of air provided that several days were allowed for the potential to fall to a constant value. As for different minerals, the single potentials shown in a normal potassium chloride solution by several minerals at 25° were as follows:

	Volts
Smooth platinum	0.634
Chalcopyrite	0.646
Pyrite	0.664
Marcasite	0.710
Galena	0.509
Chalcocite	0.488
Pyrrhotite	0.412

[1] Economic Geology 7, 1. 1912.

It appears impracticable to differentiate pyrite, marcasite and chalcopyrite under these circumstances altho galena, chalcocite and pyrrhotite plainly have somewhat lower potentials. It is not yet clear to what chemical reaction these potentials correspond. If such an electrode is short-circuited with another of low potential such as cadmium in cadmium sulfate solution there is a slow fall in the first potential which, however, regains its original value on standing. Of course it is not claimed that the potentials in potassium chloride are reversible but they are both constant and reproducible to within a few hundredths of a volt if sufficient time is allowed and may serve to differentiate some minerals. The potentials in metallic salt solutions depend entirely upon the nature and concentrations of the solutions. I have found it perfectly possible to plate metals [copper, iron] upon mineral electrodes and in the absence of metallic ions I find that a current passing from a solution to a mineral causes very little change in the mineral whereas if the current passes from the mineral to a solution both constituents of the mineral are oxidized.

There are at least three general conclusions which may be drawn from the potential measurements.

In the first place the presence of electrical conductors in ore deposits may result in chemical action at a distance. For example a solution of ferric salt at one point may be reduced in part while a solution of ferrous salt is being oxidized in part at another point, provided of course that there is both a solid and an electrolytic connection from one point to the other. By virtue of this action it appears that the oxidizing zone of ore deposits might be extended into the crust of the earth more rapidly than by diffusion alone, altho there would have to be the ionic diffusion corresponding to the passage of the current thru the solution. On account of the difference in character between surface and deep waters such currents as might arise in this way would tend to have vertical direction and I should conclude that this would carry the cations upward in veins and the anions downward.

In the second place chemical activity should correspond to the sign and amount of the potentials. Thus where oxidation is

going on, if two sulfides are in contact, the one of lower potential should be oxidized before the other. This conclusion was reached by Gottschalk and Buehler and I fully corroborate it.

Thirdly, since the deposition potentials of gold, silver and copper—to mention three out of many metals—from normal solutions of their ions are 1.35, 1.05 and 0.61 volt respectively it is evident that solutions of these salts should spontaneously deposit these metals upon mineral conductors until their concentrations were reduced to a point where they would give the same potential as shown by the minerals. These concentrations may be calculated by the well known electrochemical formulas connecting potentials and concentrations. Not only should gold deposit more easily than silver and silver more easily than copper but the deposition should occur decidedly more easily in neutral or alkaline solutions than in acid solutions and lastly somewhat more easily upon minerals of low potential like galena and pyrrhotite than upon those of higher potential like pyrite and chalcopyrite.

The experiments upon this subject have been prepared for publication in a bulletin of the United States Geological Survey which will appear shortly.

MINERALOGY.—*An aluminum arsenate from Utah.* F. W. CLARKE, Geological Survey.

Aluminum arsenates are among the rarest of mineral species, only three occurrences being known. The species are durangite, $Na(AlF)AsO_4$; ceruleite, $Cu(AsO_4)_2(AlO_2H_2)_4.4H_2O$; and liskeardite, $(AlO_2H_2)_3AsO_4.5H_2O$; each from a single locality;[1] and any new occurrence of similar material is evidently worth recording.

In 1896 a white amorphous mineral from the Sunshine mine, Mercur District, Utah, was sent to the Geological Survey by Mr. Victor C. Heikes of Salt Lake City. It was carefully analyzed

[1] An uncertain arsenate of aluminum, possibly liskeardite, has also been noted by Lacroix from Cape Garonne, France. The original liskeardite was from Cornwall. Bull. Soc. Min., 24, 27.

by Dr. W. F. Hillebrand, but the analysis seems not to have been published. It was infusible and soluble in acids, and contained some admixture of free silica, with occasional crystals of strontianite and gypsum. According to Mr. Heikes the mineral was associated with bunches of orpiment.

In the following table the actual analysis of the mineral is given in column I. In column II the figures are recalculated to 100 per cent, after deducting the extraneous silica, strontianite and gypsum. Column III gives the molecular ratios. The small amounts of alkalies and fluorine are negligible.

	I FOUND	II REDUCED	III RATIOS
SiO_2	7.08		
Al_2O_3	26.46	29.59	0.295
Fe_2O_3	0.64	0.72	
CaO	10.29	11.30	0.0202
SrO	2.10		
MgO	trace		
$(K,Na)_2O$	0.12	0.13	
As_2O_5	33.82	37.83	0.172
P_2O_5	0.94	1.05	
SO_3	0.27		
CO_2	0.88		
F	0.21	0.23	
Cl	trace		
H_2O	17.23	19.15	1.039
	100.04	100.00	

Fractional determinations of the water gave the following results:

	Per cent
Lost over sulfuric acid	2.19
Lost at 110°	3.22
Lost at 280°	10.00
Lost below redness	17.19

Part of this water, about 5.4 per cent of the original analysis, is evidently unessential, and, as has been shown in many similar instances, its amount would vary with variations in the moisture

of the air. The true or essential hydration of the mineral is uncertain, and so too is its chemical constitution. It may be a mixture of liskeardite with berzeliite, $Ca_3(AsO_4)_2$, or else a double arsenate of alumina and lime. On the one hand the analysis agrees approximately with the mixed formula $3(AlO_2H_2)_3AsO_4.3H_2O + Ca_3(AsO_4)_2$; the two molecules occurring commingled in the ratio 3 : 1. On the other supposition the formula $Ca_2(AlO_2H_2)_5(AsO_4)_3.5H_2O$ fits the analysis nearly as well. In both cases the total water is included in the formulae. How nearly the formulae agree with the analysis may be shown as follows. Recalculating Fe_2O_3 to its equivalent in Al_2O_3, and P_2O_5 to As_2O_5, and rejecting the insignificant fluorine and alkalies, the analysis assumes the form given in the following table. The composition corresponding to the two alternative formulae given above is shown in parallel columns.

	ANALYSIS	FORMULA 1	FORMULA 2
Al_2O_3	30.04	30.07	28.59
CaO	11.30	11.01	12.56
As_2O_5	39.52	37.69	38.67
H_2O	19.14	21.23	20.18
	100.00	100.00	100.00

Considering the impure nature of the original mineral a closer agreement could hardly be expected. The ambiguous conclusion is, that the mineral may be either a new species or a mixture of two already known; and the data at hand are inadequate to determine which alternative is true.

Unfortunately the Sunshine mine is no longer worked, and is badly caved in. Possibly, however, more material might be found on the dumps. A further search for it is desirable, altho it might easily escape the notice of even a trained observer. White, amorphous minerals are not conspicuous, and might well be passed over as presumably clay or kaolin.

PALEONTOLOGY.—*The nomenclature of types.* LANCASTER D. BURLING, National Museum.

In spite of the number and variety of the type names which are available to the keepers of collections,[1] the writer has found it necessary, in the preparation of a catalogue of the type and figured material represented in the Cambrian collections of the United States National Museum, to use several new names. A wider application of these terms may not obtain, but it would be impossible without their definition.

Plastotype has been proposed[2] for any artificial specimen moulded directly from any primary type. Many such specimens are included in the collections and they represent holotypes, cotypes, paratypes, etc. In order that it may be possible to differentiate these specimens the writer would propose the terms *plastoholotype, plastocotype, plastoparatype,* etc., meaning respectively any artificial specimen moulded directly from a holotype, a cotype, a paratype, etc.

It has become fairly customary for authors to select a holotype for each new species, but, if the species is a brachiopod or a mollusc, for example, and the valve chosen is a dorsal or a left, it should be possible to designate a typical form for the supposed ventral or right without making both cotypes. For this other type, concerning which (in the older rocks at least) there is little certainty of specific identity, the writer would propose the term *allotype.*[3] For example: The pygidium of a trilobite might be designated as the allotype to a cephalon chosen as the holotype; the operculum of a hyolithes, to an associated tube; a form believed to differ from the holotype in nothing but gender, to the holotype; a rib, a vertebra, and a foot might be designed as allotypes to an associated skull; etc.

Schuchert[4] has proposed that, in cases similar to the foregoing, the words holotype (ventral) and holotype (dorsal), for example, be used. Such a method, while ample in many cases, would

[1] Schuchert, Bull. U. S. Nat. Mus., no. 53, pt. 1, Introduction. 1905

[2] Schuchert, Science, new ser., **5**: p. 639. 1897.

[3] ἄλλος, another; and type.

[4] Bull. U. S. Nat. Mus., no. 53, pt. 1, p. 10. 1905.

hardly indicate the specimen upon which the first author had based his species if later events proved that species to be made up of separable parts, and would give any subsequent author the privilege of assigning the one or the other specimen as he might think best to the new species or genus, a pleasure which few authors care to reserve for those who follow them.

Allotype (like holotype, when proposed for a species described from more than one specimen) is not automatic in its application, and will be reserved for the specimens designated by the original author as typical of portions of the species other than the one upon which the species is based. Lectotype[5] has been proposed for the type of an old species selected from the original material by a subsequent author; the writer would use the term *lectallotype* for a similarly selected allotype.

BOTANY.—*The origin of maize.* G. N. COLLINS, Bureau of Plant Industry.

Introduction. Maize or Indian corn is unknown in the wild state. The plant has been in cultivation since prehistoric times and its domestication was probably very ancient. The nearest known wild relative is teosinte (*Euchlaena mexicana*) and the commonly accepted view regarding the origin of maize is that it was derived from some ancestor of this Mexican grass.

The present paper advances the hypothesis that maize originated as a hybrid between teosinte and an unknown grass belonging to the tribe Andropogoneae. This grass is believed to have been not unlike the earless varieties of pod corn (*Zea tunicata*) which are in many essential characters the very antithesis of teosinte.

These conclusions have been reached after a study of the different types of maize, teosinte, and teosinte-maize hybrids extending over seven years, during which time an extensive series of primitive varieties of both maize and teosinte have been under observation.

From the beginning two hypotheses regarding the origin of maize were kept in mind. (1) That the prototype of maize was

[5] Idem., 12.

some near relative, or ancestor of teosinte. (2) That the prototype of maize should be sought in a grass possessing the peculiar characters of *Zea tunicata*.

As the studies progressed evidence in favor of both hypotheses increased, while the possibility of harmonizing the two or of choosing between them became more and more remote. If some teosinte-like plant were considered as the prototype the unmistakably primitive characters of pod corn seemed meaningless. If the characters of pod corn were admitted as ancestral the gradations between maize and teosinte had to be disregarded or left unexplained.

That a cultivated plant constituting a monotypic genus should have originated as a hybrid between two species belonging to different botanical tribes seems, at first thought, too remote a possibility to merit consideration. But as soon as this hypothesis was tentatively adopted the apparent contradictions disappeared and all salient facts wove themselves into a connected whole.

Maize intermediate between the Maydeae and Andropogoneae. The intermediate nature of the floral characters of maize has been the chief reason for doubting the propriety of separating the Andropogoneae and Maydeae as distinct tribes. The only important distinction between these groups is the existence of perfect-flowered spikelets in the Andropogoneae and the complete separation of the sexes in the Maydeae.

Aside from the evidence afforded by maize, the importance of this distinction may be questioned, but so far as known the only species that completely bridges the gap is *Zea mays*. It bridges the gap not as a natural intermediate form, but because of its variable nature, which in itself supports the idea that maize is of hybrid origin.

The primitive nature of podded maize. The chief distinction between pod corn (*Zea tunicata*) and the ordinary varieties of maize, is that the floral bracts or glumes of the female spikelets are more fully developed in pod corn and completely enclose the seed while in ordinary maize the glumes are reduced to scales at the base of the seed. Associated with this is a corresponding

development of the glumes of the terminal inflorescence, which, tho not changed in form, are much larger in podded plants.

If podded plants are isolated and kept from crossing with non-podded plants for a few generations, there will usually result a still greater divergence from the ordinary type of maize. Plants will appear in which the lateral inflorescence or ear is aborted while the terminal inflorescence will be greatly enlarged, containing both stamens and pistils. These may be borne either in separate spikelets, in separate flowers of the same spikelet, or in perfect flowers. Plants of this earless type of pod corn possess no characters which would exclude them from the Andropogoneae. The constant recurrence of such plants among many varieties of corn is certainly a strong indication that some perfect-flowered grass has figured in the ancestry of these plants.

Maize closely related to teosinte. Plants of *Zea canina* Watson, first described as a wild maize, were afterward shown by Harshberger to represent the early generations of a hybrid between ordinary maize and teosinte. Many of the less improved varieties grown by the natives of Mexico and Central America show almost as pronounced evidences of teosinte blood. From these undoubted hybrids thru to the most uniform and highly developed varieties of the corn-belt, there is an unbroken series. In view of this continuity may we not consider the possibility that all the teosinte-like characteristics of maize have originated in the same way? On the other hand, plants from seed of wild teosinte collected for the writer by Mr. H. V. Jackson, of Durango, Mexico, show all stages between the *Zea canina* type and what we assume to be pure teosinte. These intermediate types are not rare. With but one exception such examples have been found among the plants grown from every sample of teosinte seed secured from that region.

Harshberger as a result of his studies of teosinte-maize hybrids concluded that teosinte must be considered as the nearest known wild relative of maize, and suggested three possibilities regarding the botanical nature of maize. "(1) That maize is generically and specifically a distinct plant. . . . . (2) That maize,

as we now know it, owes its origin to the crossing of teosinthe, as one of the parents, with the pollen of an extirpated closely related grass. . . . . (3) That Indian corn is the result of a cross between teosinthe and a race or variety of the plant produced by successive cultivation of the wild plant until its characters as a variety or a race have become fixed."[1]

Harshberger accepted the third hypothesis as the most probable and discredited the idea that maize had orginated as a hybrid between even closely related species. In none of these hypotheses is consideration given to the evidence afforded by the podded varieties of maize. To explain maize as a hybrid we must assume in addition to teosinte another parent radically diverse from it. For the other parent neither an improved variety nor a closely allied species will account for the appearance of characters which are the very antithesis of those peculiar to Euchlaena.

Euchlaena is without doubt the nearest known relative of maize, but to derive maize from the stock from which Euchlaena descended, it would be necessary to assume that domestication stopped the evolutionary progress of maize while the line of descent that has terminated in Euchlaena continued to evolve by developing a more complete specialization of parts. In the attempt to explain the origin of maize from some teosinte-like ancestor, the chief difficulty is, not to explain the specializations of maize, but to account for the persistence of so many primitive characteristics.

Euchlaena more highly specialized than maize. From an evolutionary standpoint Euchlaena is more highly specialized than maize. The closeness of the homology between the male and female inflorescence of Zea indicates at once a less specialized form than Euchlaena, in which the differentiation between male and female flowers is much more complete. The origin of the pistillate inflorescence of Euchlaena is more difficult to trace than is the origin of the ear of maize.

A detailed comparison of the parts of the female inflorescences

[1] Harshberger, J. W. Fertile crosses of teosinthe and maize. Garden and Forest, pp. 522–523. December 30, 1896.

of Zea and Euchlaena emphasizes the specialized nature of the latter genus. The glumes that surround the female flowers in maize are relatively undifferentiated. There is an almost regular diminution in size from the outer glume which is somewhat more specialized, to the innermost which is the least developed. In Euchlaena, on the other hand, the specialization is much more advanced. The outer glume is greatly developed. The others are all reduced.

The relatively slight differentiation between the male and female inflorescence in maize is further indicated by the fact that the development of staminate flowers in the pistillate inflorescence and of pistillate flowers in the staminate inflorescence is of very common occurrence. When grown under unusual conditions such as obtain in a greenhouse or in very sterile soil, one can seldom find plants entirely free from pistillate flowers in the terminal inflorescence. Variations of this nature have never been observed in pure teosinte.

In Zea the rachis is only slightly pitted, while in Euchlaena it is highly specialized. Each joint is developed into a cup containing the seed, the opening of the cup being covered by the specialized lower glume.

Zea is the only representative of the Maydeae which has retained the ancestral character of grouping the pistillate spikelets in pairs. This fact alone makes the derivation of Zea from any existing member of the Maydeae improbable, since it would necessitate the assumption that the second spikelet of the pair has first been lost and then regained.

Almost the only floral character which is more specialized in maize than in Euchlaena is the occurrence of numerous rows in the ear and in the central spike of the staminate inflorescence, a character not shared by any other member of the Maydeae. It seems clear that this character must have arisen in connection with a more primitive form since it is associated in both the male and female inflorescence with the primitive character of paired spikelets. Had a multiplication of parts or fasciation taken place after the male and female inflorescence had become differentiated, as in Euchlaena or other members of the family, the rows in the

maize ear would not always be present in even numbers, a fact that results from the spikelets being paired.[2]

The characters in which Zea is more highly specialized than the other members of the Maydeae are those which we may feel reasonably certain have been developed with the coöperation of human agencies. The most important and fundamental of these specializations is the rigid rachis. The acquisition of this character, or rather the loss of the brittle rachis, has been the most important step in the domestication of all the principal cereal crops. To be able to scatter its seeds is an essential character in a wild grass, while to be successfully cultivated this natural dissemination must be avoided.

The other specializations possessed by Zea are the large size of the seeds, the annual habit, and a restricted period of flowering, all of which may be looked upon as resulting from domestication, or at least, being of advantage in a domesticated plant.

Origin of the maize ear. The opinions regarding the origin and morphological significance of the ear of maize fall into two groups: (1) Those which look upon the ear as having resulted from the fasciation of branches corresponding to the lateral branches of the staminate inflorescence, and (2) those which hold that the ear is the homologue of the central spike of the staminate inflorescence. On more complete analysis the differences between the two ideas disappear. In one sense, both may be right, yet both seem incomplete. The ear is undoubtedly the homologue of the central spike, and from this viewpoint it appears entirely superfluous to predicate the fasciation of branches to account for its origin. This homology, however, throws little light on the question of origin. The central spike is quite as anomalous as the ear, and as much in need of explanation. No other member of the Maydeae has a many-rowed central spike, and to account for the central spike of maize by the fasciation of simple branches that resemble those of the staminate inflorescences of Euchlaena may not seem unreasonable.

[2] As might be expected theoretically the early generations of hybrids between the single-rowed teosinte and the double-rowed maize occasionally result in an odd number of rows. Well formed ears with 3, 5, 7 and 9 rows have already been observed in such hybrids.

With an appreciation of the relationship of maize to some perfect-flowered grass with a terminal inflorescence, the origin of the central spike, and with it the ear, may be looked for in quite another direction. If one assumes a profusely branched panicle in which the branches have been reduced until each branch is represented by a single pair of spikelets the inflorescence becomes a spike. If such a reduction of branches is confined to the upper part of the inflorescence a type is produced resembling that of maize, bearing four-rowed branches at the base and ending in a many-rowed central spike.[3]

The chief objection to this explanation is that in ordinary varieties of maize the transition from well developed branches to single pairs of spikelets is abrupt. Only in rare instances are the pedicles of the lowest spikelets of the central spike elongated or the uppermost branches of the tassel greatly reduced. In the podded varieties, however, which we are now looking upon as representing an ancestral type, the transition is frequently more gradual. In plants having only a terminal inflorescence it is often impossible to distinguish between branches and pairs of spikelets.

Ordinary maize intermediate between Euchlaena and earless pod corn. The podded varieties of maize are commonly supposed to have arisen as mutations from ordinary maize. Numerous cases have been reported of podded plants occurring in supposedly uncontaminated strains. It may be urged that the sporadic occurence of this character is to be explained by the chance admixture of pollen from some existing podded plant, and that it is not in reality a mutation. For purposes of the present argument it makes little difference. Whether the type continually recurs as a mutation, is the result of a single mutation, or has persisted as a distinct type evolved by more gradual means, it possessses characters of the more primitive grasses and must be considered as indicating a more or less remote stage in the development of maize. None of the characters distinguishing Euchlaena from maize are shared by pod corn. On the supposition of a single

[3] This explanation was suggested to the author by Mr. F. V. Coville.

prototype a choice must be made between the two lines of development, they can not be combined. With respect to all the differences between podded varieties of maize and teosinte, the ordinary varieties of maize stand intermediate. If the three are to be forced into a linear series, we must proceed from the Euchlaena-like plant thru maize to pod corn, or from pod-corn, thru maize to some near relative of teosinte.

It seems more reasonable to look upon teosinte and the prototype of pod corn as having descended along divergent lines in different geographical regions, and upon maize as a hybrid between the two, following the transfer by primitive man of a domesticated prototype of pod corn into the natural habitat of teosinte. That maize and teosinte are inextricably mixed seems certain, but the more highly specialized nature of teosinte precludes any but a very remote common ancestry. Even on the assumption of a single common ancestor and a domestication of maize so ancient that teosinte has since become specialized, the recurrence of pod corn has still to be explained. On the assumption of a single prototype for maize it is, to say the least, remarkable that pod corn should revert to, or retain so many, primitive characters and yet not approach teosinte in any respect.

Since so much importance is here placed on the differences between pod corn and teosinte and the intermediate nature of maize, it may be well to enumerate such of these differences as may be readily described. It should be noted that in practically every case where there is pronounced divergence between teosinte and pod corn, maize shows characters of an intermediate nature, and that these characters are usually variable.

1. The glumes of the staminate inflorescence are short in teosinte, long in pod corn. In maize they are of variable length, never longer than in pod corn, and seldom as short as in teosinte.

2. In teosinte perfect flowers in the staminate inflorescence have never been observed. In pod corn they are the rule. In maize they are a common abnormality.

3. In teosinte branches are developed from practically every node. In the extreme type of pod corn no branches develop, and even the lateral female inflorescence is suppressed, all seed

being borne in the terminal panicle. In maize all gradations between these two extremes occur.

4. In teosinte all primary branches terminate in a staminate inflorescence. In the branched forms of pod corn staminate flowers have not been observed on any of the branches. In maize staminate spikes at the summit of the female inflorescence occur as an abnormality in practically all varieties.

5. In teosinte each internode of the rachis of the female inflorescence is specialized into a cup, in which the seed is contained. In the female inflorescence of pod corn all spikelets are stalked, resembling the spikelets of the staminate inflorescence, while the rachis is only slightly pitted. In maize the female spikelets are sessile, while the rachis is pitted more deeply than in pod corn and less so than in teosinte.

6. In teosinte the floral bracts of the female spikelets are highly differentiated, the lower being large and horny, completely closing the opening in the pitted rachis, while the others are greatly reduced. In pod corn the glumes of the female spikelets are all well developed and are no more specialized than those of the male inflorescence. In maize they are all reduced but the lower are more indurated than the upper.

7. A combined result of the last three characters is that in teosinte there is practically no resemblance between the male and female inflorescences, the differentiation extending even to the total loss of one of the spikelets of each pair in the female inflorescence. In pod corn the differences between the terminal and lateral inflorescences are slight. In maize the differentiation is less than in teosinte and greater than in pod corn.

8. In teosinte there is always a secondary branch in the axil of every prophyllum that encloses a primary branch, and if tertiary branches, or branches of a still higher order occur, the most highly developed branch is always to be found in the axil of the prophyllum. In pod corn branches have never been observed in the axils of prophylla. In maize, branches in the axils of prophylla occur as very rare abnormalities in several varieties, while in *Zea hirta*, a type of maize from the Mexican plateau, such branches are normal.

9. In teosinte double-flowered female spikelets have never been observed. In pod corn two-flowered female spikelets, while not normal, are of very frequent occurrence. In one plant 20 per cent of the female spikelets were double-flowered. In maize double spiklets do occur, but rarely, and when present, only a few of them are found on any single ear, the highest number observed as yet being 6, or about 1 per cent.[4]

Natural dissemination in pod corn. If earless pod corn is a reversion toward one of the wild prototypes of maize, we should naturally expect it to exhibit characters that would better fit a plant for existence in nature. The most important difference between the wild and domesticated cereals lies in the nature of the rachis, and if the present assumption is correct, we have reason to expect the rachis of pod corn to be more brittle than that of the cultivated varieties.

In descriptions of pod corn attention is usually called to the greatly reduced cob as one of the distinguishing features. This reduction in the size of the cob is so conspicuous that the Sconce variety of pod corn has been dubbed "cobless," and Mr. Sconce is now endeavoring to reduce the size of the cob in commercial varieties by crossing them with the "cobless variety."[5] A careful comparison of the two types, however, shows that at least a part of the reduction is more apparent than real. In forming an idea of the diameter of the cob of an ordinary variety the glumes are included in the measurement, since these, with their more or less thickened bases, are firmly attached to the rachis. In pod corn the spikelets are pedicelled and when the seed is removed only the naked rachis remains.

After making due allowance for this morphological difference, however, the cob of pod corn is really smaller and much more easily broken than in ordinary varieties. The more brittle rachis of the pod varieties, and the importance of this character as a natural means of dissemination, was forcibly called to mind by

[4] Kempton, J. H. Two-flowered female spikelets in maize. Bulletin 278, Bureau of Plant Industry, U. S. Dept. of Agriculture. 1913.

[5] Sconce, H. J. Scientific corn breeding. Ann. Report Amer. Breeders' Assoc. 7: 49. 1912.

finding volunteer corn plants in our experimental field at Lanham, Md. These on examination proved to have arisen from podded ears, the tips of which had broken off, fallen to the ground, and germinated. Breaking of the cob caused by the crowding of the grains is a phenomenon that sometimes occurs in non-podded varieties, but much less frequently than in podded plants. In one row of podded plants the cob was found to have broken naturally in over half the plants.

The definite tendency toward a brittle rachis in podded plants and the demonstration that this character may serve as a natural means of dissemination, are additional evidence that the podded varieties of maize are not meaningless monstrosities, but definite reversions to a perfect-flowered ancestor. This ancestor could have been only distantly related to Euchlaena and according to present taxonomic ideas must have belonged in the tribe Andropogoneae.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

CHEMISTRY.—*The effect of exposure on bitumens.* PREVOST HUBBARD and C. S. REEVE, Office of Public Roads. Eighth International Congress of Applied Chemistry, 1912.

This paper describes investigations conducted for a year on eight typical samples of bituminous road materials which were subjected to exposure tests for periods of one, two, four, six, eight and twelve months. Changes in weight, consistency and insoluble organic matter were determined at the end of each period.

All of the materials showed an increase in hardness due to exposure and an increase in insoluble organic material. Tar products lost weight continuously throughout a period of twelve months, while the petroleum and asphalt products showed either an increase in weight or only a comparatively slight loss. An increase in insoluble organic matter was noted which was considerably in excess over that calculated from the percentage loss in weight of the samples. This increase accompanies the hardening of the materials.

It is concluded that the hardening of all bitumens upon exposure is not due to loss of the lighter constituents by volatilization alone, but also to oxidation and reactions occurring between certain constituents of the bitumens. Such reactions would seem to account for the increase in insoluble organic matter. The increase in insoluble organic matter in tars demonstrates that so-called free carbon is actually formed in tars upon exposure. C. S. R.

CHEMISTRY.—*Coke-oven tars of the United States.* PREVOST HUBBARD. Circular No. 97 of the Office of Public Roads, U. S. Department of Agriculture. 1912.

A report of an investigation upon tars from the various by-product coke-oven plants in the United States. A table gives the analyses of twenty-siz representative crude tars, and the results are discussed from the standpoint of the value of these materials for the preparation of road binders. C. S. REEVE.

PLANT PATHOLOGY.—*The diseases of ginseng and their control.* H. H. WHETZEL and J. ROSENBAUM. Bulletin 250, Bureau of Plant Industry, U. S. Department of Agriculture.

The diseases attacking *Panax quinquefolium* are grouped as blights, wilts, galls, and root rots.

Under blights are included Alternaria blight, Phytophthora mildew, Vermicularia stem anthracnose, Pestalozzia leaf anthracnose, papery leaf-spot and damping-off disease of seedlings. Only the first two of these are discussed at length.

The Alternaria blight is very common. It causes dark brown cankers on the stem and large dead spots in the leaves. Very often a shelling of the berries may result. Inoculation experiments have proved it to be due to *Alternaria panax.*

The Phytophthora mildew occurs both in Japan and the United States. It causes a damping-off of the leaf petioles, spots on the leaf, and rotting of the root. It is caused by *Phytophthora cactorum.*

The control methods for these two diseases are prompt removal of diseased plant parts and spraying with bordeaux.

The wilts include the Fusarium wilt described by Reed and the Acrostalagmus wilt, first described by Van Hook. The latter appears very early in the spring and is detected by a wilting of the tops and the yellowing of the sap tubes. No remedies are given.

Nematode root-gall is the only disease described under galls. The authors give a short account of this disease and suggest that it be controlled by cutting away the galls, dipping the roots in a solution of formalin, one part to one hundred parts of water, and planting in clean soil.

Under rots are discussed "rust" or fiber rot, soft rot, Sclerotinia white rot and Sclerotinia black rot.

"Rust" attacks roots of all ages and is caused by *Thielavia basicola.* Inoculation experiments are not reported. As a remedy the use of

new soil, sterilization of old soil, and the application of acid phosphate is recommended. Corrosive sublimate should not be used.

Soft rot appears to be very destructive in wet seasons. The causal organism is not known. Tile drainage and sterilization of the soil is recommended.

Sclerotinia white rot is caused by *Sclerotinia libertiana* which survives the winter by means of sclerotia. Removal of diseased plants before sclerotia have had time to form is suggested as a remedy.

Sclerotinia black rot differs from the white rot in that it causes a black discoloration of the outer tissues of the root. It is caused by *Sclerotinia panicis*. The peculiarity of the parasite is that it develops and produces the disease during cold weather. Removal of plants and sterilization of soil is recommended.

The latter part of the bulletin deals with spraying, soil sterilization, fertilizers, and drainage in the cultivation of ginseng. J. R.

BACTERIOLOGY.—*A study of the virulence of cultures of Bacillus pestis of various sources and ages.* GEORGE W. MCCOY and CHARLES W. CHAPIN. Public Health Bulletin No. 53, U. S. Public Health Service, 1912.

A large number of cultures of plague bacilli derived from various sources covering a number of years were used to inoculate laboratory animals for the purpose of studying the differences in virulence. Practically all of the cultures under three years of age were found possessed of a high degree of virulence while a majority of those more than three years old were of low virulence. Certain cultures tested three years previously were found to have lost very materially in virulence in the interval. The origin of the culture appeared to have no noticeable influence upon the retention or the loss of virulence. G. W. M.

BACTERIOLOGY.—*Bacterium tularense the cause of a plague-like disease of rodents.* GEORGE W. MCCOY and CHARLES W. CHAPIN. Public Health Bulletin No. 53, U. S. Public Health Service, 1912.

This is a paper on a remarkable organism which has been shown to be the cause of a plague-like disease of rodents, found originally in California ground-squirrels (*Citellus beecheyi*, Richardson.)

In smears from tissue the organism is found as a minute rod lying free or in the leucocytes. It stains well with aniline gentian-violet carbol-thionin, carbol-fuchsin but not with methylene blue. Cultures on ordinary media have invariably failed but growths were obtained on Dorset's egg and coagulated egg yolk gave very satisfactory results.

Early cultures proved lethal whether injected subcutaneously or merely rubbed on the abraded surface. Late cultures killed animals only when injected subcutaneously. The cultures were pathogenic for mice, rabbits, guinea-pigs, ground-squirrels and monkeys. Efforts to produce an immune serum were unsuccessful.

The serum of susceptible animals was found not to agglutinate the organism but that from animals naturally immune gave positive reactions.

The serum from certain human beings was found to agglutinate in high dilutions and nearly all human sera agglutinate in low dilutions. Complement fixation work gave results parallel with agglutination tests.

The lesions of the chronic form of the disease bear a strong resemblance to those of tuberculosis. G. W. M.

EPIDEMIOLOGY.—*Transmission of poliomyelitis by means of the stable fly (Stomoxys calcitrans)*. JOHN F. ANDERSON, Director Hygienic Laboratory, and WADE H. FROST, Passed Assistant Surgeon, U. S. Public Health Service. Public Health Reports **27**: 1733. October 25, 1912.

Anderson and Frost have detailed in this paper the results of attempts to confirm Rosenau and Brues in their reported transmission of poliomyelitis through the agency of the stable fly, *Stomoxys calcitrans*. The authors conclude that their results, in confirmation of those announced by Rosenau and Brues, would seem to demonstrate conclusively that poliomyelitis may be transmitted to monkeys through the agency of the stable fly. They add that it remains for further work to decide whether this is the usual or the only method of transmission in nature. W. H. F.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the meeting of the Anthropological Society of Washington in the new building of the National Museum on Tuesday afternoon, November 19, President George R. Stetson in the chair. MR. JAMES MOONEY of the Bureau of American Ethnology lectured on *The Gaelic language of Ireland.*

The lecturer outlined the history of the Celtic nations, of whom the Gaels of Ireland and Scotland form a part, from their first acquaintance with the Greeks about 600 B. C. to the storming of Rome in 390 B. C. He referred to their alliance with Alexander the Great, their invasion of Asia Minor and colonization of Galatia in 278 B. C., and to the final subjugation and Latinization of the continental Celts by the Romans about the beginning of the Christian era.

Gaelic is the oldest living language in Europe, unless we except modern Greek, and it closely resembles Latin in many of its roots.

The Gaelic colonization of Ireland probably dated as far back as 1000 B. C. The island was known to the Greeks under a form of its native Gaelic name of Eire as early as four centuries before Christ. The ancient annals mention several earlier races or colonizations, the most important being the Firbolg, probably a part of the Belgae of the continent. They continued to exist as a distinct people under their own chiefs up to the sixth century or later.

The alphabet of pre-Christian Ireland was the Ogam (Ogum), a system of straight lines or dots ranged along either side of a base line, and somewhat resembling a cross between the Morse alphabet and the cuneiform inscriptions. It was used chiefly for monumental inscriptions, and continued in use to some extent up to the tenth century. The modern Gaelic alphabet, consisting of seventeen letters, is an adaptation from the Roman.

Mention was made of some of the most ancient manuscripts, some of which have been already translated and others of which are now under translation by the Irish Texts Society. Under the Penal Laws, from 1691 until about 1800, the whole native population was practically debarred from education. Under the so-called National School System, established in 1831, the national language continued to be proscribed, resulting in its rapid decline. The great famine of 1845–7 with the ensuing wholesale emigration reduced the Gaelic-speaking population by nearly one-half within twenty years, the great majority of those

remaining being entirely illiterate. In 1878 the first concession to the native language was made by the national schools. In 1893 the Gaelic League, under the presidency of Dr. Douglas Hyde, began an active propaganda for the restoration of the language to its proper status, with the result that it is now taught in 3000 of the 8000 governmental "national" schools, as well as in a large number of private and denominational schools, a whole flood of modern Gaelic literature covering every subject of intellectual interest is coming from the press, and the Gaelic language has been made an essential for matriculation in the new National University of Ireland beginning with 1913. Out of its own funds the League also maintains ten normal colleges for the training of teachers in the language, in several of which schools the entire course of instruction is thru the Gaelic. The census just completed shows that Gaelic is still the home language of nearly 6,000,000 persons in Ireland above the age of three years.

Outside of Ireland the Gaelic speakers in Scotland, England, the United States, Canada and elsewhere probably number considerably over a million. Prince Edward Island and adjacent parts of Nova Scotia have a compact body of about 100,000, mostly descendants of emigrants from the Hebrides. In this country Gaelic instruction is now conducted in several universities and a translation of the *Rubaiyat*, in Gaelic language and type, was recently published in Chicago.

WM. H. BABCOCK, *Secretary*.

THE BOTANICAL SOCIETY OF WASHINGTON

The 84th regular meeting of the Society was held at the Cosmos Club, December 3, 1912. The program included the following papers:

Summary of studies of glomerella: C. L. SHEAR. To be published as a bulletin of the Bureau of Plant Industry.

Probable origin of maize: G. N. COLLINS. Published in this number of the Journal.

The effect of lime on the alkali tolerance of wheat seedlings: J. A. LE CLERC and J. F. BREAZEALE. To be published as a bulletin of the Bureau of Chemistry.

C. L. SHEAR, *Corresponding Secretary*.

CORRECTIONS, VOL. 2

P. 62, line 15, for "farm" read "form."
P. 109, line 14, for "Utah" read "Idaho."
P. 213, line 1, for "kam-trawl" read "beam-trawl."
P. 213, line 6, for "macruriod" read "macruroid."
P. 452, last line, omit "as."
P. 453, line 26, for "former" read "latter."
P. 455, line 10, for "they" read "the cathodes."
P. 456, line 17, for "1.01827" read "1.0182_7."

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